

## **BRIEFING ON GLYCEMIC INDEX**

The effect of carbohydrates on weight management and health continues to be of interest to consumers. Following on the heels of the low carbohydrate trend, there appears to be a renewed interest in the concept of Glycemic Index (GI) as a method to select carbohydrate foods.

Much of the discussion focuses on whether GI can be used as the basis of a weight loss regimen, but many are turning to the GI without first understanding what it represents or how it works.

This briefing paper provides an overview of the GI in the first section of “Question and Answers” followed by in-depth look at current research into GI and its impact on weight loss, management of chronic diseases and benefits for long-term health.

### **What is the Glycemic Index?**

The GI ranks foods that contain carbohydrates on how they affect blood glucose, commonly referred to as blood sugar. Foods that raise blood glucose levels more have a higher GI than those that raise blood glucose less.

### **What foods contain carbohydrates?**

Carbohydrates that the body can digest are starches and sugars. Sugar and sweeteners, grains, fruits, vegetables, beans, milk and most products made with or from these foods contain varying amounts and types of carbohydrates.

### **Why is Glycemic Index Important?**

There has been much discussion about the difference between “bad carbs” and “smart carbs,” and GI provides a more accurate picture of the quality of a carbohydrate. Generally speaking, the lower the GI, the better is the quality of the food that supplies the carbohydrate.

### **How is GI determined?**

The GI is determined by measuring the change in blood glucose after eating a carbohydrate ... the “glycemic response.” This measure is then compared against a standard amount of glucose, which has a GI of 100. White bread can also be used for comparison but produces a different value for GI because it does not cause as great a change in blood glucose as does glucose. Using glucose as the standard, foods with a GI of 55 or below are considered “low,” those with a GI of 56-69 are considered “medium,” and those with a score of 70 or higher are considered “high.”

### **What is the Glycemic Index for Fruits and Vegetables?**

Nearly all fruits and vegetables have a low GI. There are a few that have a higher GI, but respected health professionals such as Barbara Rolls at Pennsylvania State University strongly recommend that they not be excluded from a healthy diet because of their nutrient, fiber and phytochemical content.

### **Can GI be used as a method for losing or maintaining weight?**

More research is needed to clarify direct relationships between GI and weight loss and maintenance, but it can be a useful method for monitoring carbohydrate choices as part of a healthy diet. In general, foods that have low GI values are those that are recommended for health because of their high nutrient content. Because foods like fruits and vegetables tend to be lower on the GI scale, choosing low GI foods more often may provide health benefits including lowering cholesterol, controlling appetite and lowering risk for heart disease.

Most nutritionists agree the best method to manage weight is to exercise regularly, limit calories, eat a wide variety of colorful fruits and vegetables, focus on low-fat sources of protein, choose whole grains, eat and drink fat-free or low-fat dairy products and limit saturated fats and trans fats. *Remember, the best diet is one that considers not just weight management, but overall nutrition for long-term health.*

### **Should all low-GI foods be a regular part of healthy meals and snacks?**

No. If choosing a diet based on GI, it is important to look not only at the GI level of a food but also the vitamins, nutrients and fiber that food provides. There are some low GI foods, such as ice cream or candy bars, that are high in calories and fat but low in nutrients and should not be eaten frequently.

### **Is GI a precise measurement?**

No. GI should be considered a general measure. The GI of a food is affected by several factors: ripeness of fruits and vegetables, physical form of the food (whole vs. mashed), varieties within a class of food, processing (grinding, pressing, chewing), preparation method and length of cooking, and composition of the meal. A food that is baked may not have the same GI when it is boiled, for example. Food eaten as part of a larger meal also has a different GI level because the other foods affect the glycemic response.

### **What is Glycemic Load?**

Glycemic load is considered to be a more useful measure because it considers both the type *and* quantity of carbohydrate consumed. It is a measure of both the GI of a food and the amount of carbohydrate in the portion consumed. Glycemic load is determined by multiplying the GI by the number of carb grams in the serving of food and dividing by 100. Let's say you're drinking a standard ½-cup serving of orange juice. The GI of orange juice is about 50, and a standard serving provides 13 grams of carbohydrate. The glycemic load is thus 6.5 (50 times 13 divided by 100). A portion of food with a

glycemic load of 10 or less is considered “low,” those with a glycemic load of 11-19 are considered “medium,” and a glycemic load of 20 or greater is considered “high.”

### **What foods have a high glycemic index and glycemic load?**

Generally, foods high in starch and low in fiber, like white bread, tend to be higher on the GI scale. Interestingly, because table sugar has a medium GI, foods with high amounts of sugar such as sweetened cereals, candies, sodas and sweetened juice drinks generally have a medium GI. This is another reason that people should focus on the type of food they are selecting rather than just the GI.

### **Do high-GI foods increase hunger?**

It has been suggested that foods with a high GI increase hunger by stimulating the release of insulin, but studies have shown mixed results. There is no evidence that insulin, at concentrations found in humans in response to eating carbohydrate-containing foods, triggers weight gain by increasing hunger. Also, large population based studies do not show a relationship between GI and body weight.

Many low-GI foods, like most fruits and vegetables, are high in fiber as well as water. These components of fruits and vegetables contribute to a feeling of satisfaction after eating and may help to lessen feelings of hunger.

### **Can GI be used as a tool to manage diabetes?**

For people with diabetes, choosing low GI foods more often, *in conjunction with monitoring total carbohydrate intake*, may help to control blood glucose levels. The American Diabetes Association encourages those with diabetes to consider several important points:

- GI should not be used alone, but in conjunction with other nutrition strategies;
- the GI for any particular food can vary considerably and measures the response of an individual food consumed by itself; and
- GI does not predict post-meal blood glucose response as accurately in those with diabetes as it does in healthy persons.

### **Beyond weight management, are there other benefits to a diet based on GI measurements?**

Most low-GI foods tend to be low in calories and fat, and high in nutrients; some are good sources of fiber and/or phytochemicals, and therefore are considered important components of a healthy diet. However, GI levels should not be the sole barometer of a healthy diet. Some foods with high GI levels are very nutritious, while some with low GI levels have little nutritional value.

Several large studies suggest a relationship between GI, glycemic load and cardiovascular disease. Low GI diets have had a positive effect on risk factors such as lipids in people with coronary artery disease and in people with diabetes. However, long-term studies are needed to confirm the potential effectiveness of low GI diets in the prevention of heart disease.

## **Where can a list of the GI of foods be found?**

Canadian Diabetes Association:

Provides practical information on how to use the GI to choose foods wisely.

[www.diabetes.ca/Section\\_About/glycemic.asp](http://www.diabetes.ca/Section_About/glycemic.asp)

Prevention:

Contains a consumer friendly list of the GI values of foods.

<http://www.prevention.com/article/0,5778,s1-3-61-114-2636-1,00.html>

University of Sydney, Australia

Contains information on GI and use of the GI symbol in Australia.

[www.glycemicindex.com](http://www.glycemicindex.com)

American Journal of Clinical Nutrition, 2002, Volume 76: pages 5-56.

“International table of GI and glycemic load values: 2002.”

Updated list of GI and glycemic load values.

<http://www.ajcn.org/cgi/reprint/76/1/5>

## **AN IN-DEPTH LOOK AT THE GLYCEMIC INDEX AND GLYCEMIC LOAD**

Carbs – low, high, slow, fast, good, bad – what does it all mean? And how does it translate into choosing healthy foods?

One approach that has been proposed as a method to select carbohydrate foods is the glycemic index (GI). Simply stated, the GI ranks carbohydrate foods based on their effect on blood sugar after eating. The concept of the GI was introduced in 1981 when it was noted that various carbohydrate foods produced different blood sugar responses (1). Its implementation and use have remained controversial since that time, especially in the United States.

The purpose of this briefing is to discuss the GI and its use as a tool for making food choices by healthy people and people with food related disorders. The nature of the controversy surrounding GI is addressed with considerations for research.

### **A Primer on Carbohydrates**

The primary function of carbohydrates is to provide energy. All the cells of the body rely on energy, and carbohydrates are the best utilized. The brain and nervous system use carbohydrate almost exclusively for energy. Additionally, unprocessed or minimally processed carbohydrate foods contain fiber and phytochemicals which provide important health benefits as well. Fiber from carbohydrate foods is important for health of the digestive tract and some forms help to reduce cholesterol. Phytochemicals in fruits, vegetables and grains are being studied for their roles in the prevention of cancer and cardiovascular diseases as well as other diseases.

### **Forms of carbohydrate in the diet**

Carbohydrates occur in food in the forms of sugar, starch and fiber. **Sugars** are found in foods such as table sugar (as sucrose), honey (as glucose and fructose), milk (as lactose) and fruit (as fructose). The most common dietary sugars are the mono-saccharides (glucose, fructose and galactose), and di-saccharides (sucrose, lactose and maltose). **Starches** and **fibers** are long chains of sugar (glucose) units bound together. Starches are digestible and are found in vegetables, grains (wheat, oats, barley, rice, etc.) and grain products (breads and cereals, bakery goods), legumes (dried beans), and a few fruits. Fiber is not digestible and is found in all whole fruits and vegetables, legumes, whole grains and whole grain products.

### **Digestion and absorption of foods with carbohydrate**

During digestion, starch is broken down to single sugar units so that they can be absorbed. This process takes about 30-60 minutes. Fiber cannot be digested by enzymes in the human stomach or small intestine and therefore is not absorbed into the body. Because sugars are in their simplest form, they require little or no breakdown during digestion and are rapidly absorbed into the bloodstream. After absorption, all sugars are ultimately converted to **glucose** – the form in which sugar circulates in the blood.

### Glucose in the blood

The blood glucose will begin to increase after eating a food that contains carbohydrate. Levels of glucose in the blood are maintained within a certain range by two hormones with opposing actions: insulin and glucagon. When blood glucose rises, insulin is released from the pancreas to allow body cells to take up the glucose from the blood, lowering blood glucose levels. When blood glucose falls, glucagon is released to increase blood glucose. The **glycemic response** refers to how quickly and how long the blood glucose levels rise after a meal containing carbohydrate. Re-stated, the glycemic response is the rate, magnitude and duration of the rise in blood glucose that occurs after a meal or food containing carbohydrate is consumed.

The composition of the food or meal affects the glycemic response. When consumed alone, carbohydrates raise the level of sugar in the blood relatively quickly because they are rapidly emptied from the stomach into the small intestine, they require little or no 'work' by the digestive system, and they are rapidly absorbed. However, when consumed as part of a mixed meal that also includes protein, fat and fiber, the increase in the blood sugar will occur more slowly. Food is emptied from the stomach more slowly, and therefore the rate at which the sugar enters the small intestine where it is absorbed is delayed, causing a slower rise in blood glucose.

### Carbohydrate recommendations

There is not a Recommended Daily Allowance for carbohydrate as there is for protein, vitamins and minerals. Recommendations for carbohydrate intake are individualized based on calorie and health needs. The recommendations from the Institute of Medicine state that the minimum amount of carbohydrate an adult should consume is 130 grams per day (2). The 2005 Dietary Guidelines for Americans (3) recommend that 45% to 65% of calories be obtained from carbohydrate foods, of which no more than 25% should come from added sugars. Based on a 2000 calorie diet, this would be equivalent to 225 to 325 grams per day. Put in perspective, a standard slice of bread contains about 15 grams of carbohydrate; a ½ cup serving of carrots has about 8 grams, and a small apple has approximately 14 grams (4).

The recommendation for fiber intake from the Institute of Medicine is 38 and 25 grams for men and women 50 and under, and 30 and 21 grams for men and women over 50 (2). The Dietary Guidelines recommend a daily fiber intake of 14 grams per 1000 calories (3).

### The Glycemic Index

Although carbohydrate foods require little or no digestion, there are some differences in how rapidly they enter the bloodstream. For instance, fructose must be converted to glucose in the liver, causing some delay in how rapidly it enters the bloodstream. There are two different types of starch, amylose and amylopectin, and they appear in varying amounts in foods. Amylopectin is more rapidly broken down into individual glucose

units, so foods which contain a high proportion of amylopectin will raise blood sugar levels more rapidly, and thus have a higher GI value.

The GI is a measure of the change in blood glucose following ingestion of foods containing a specific amount of carbohydrate relative to a standard – either glucose or white bread - containing the same amount. Thus, the GI compares equal quantities of carbohydrate, providing a measure of carbohydrate quality but not quantity. In general, the lower the GI the better is the quality of carbohydrate. For example, the glycemic response following consumption of a glass of orange juice that contains 50 grams of carbohydrate would be compared to the glycemic response after consuming a beverage containing a standard 50 grams of glucose. Lower GI levels indicate a lower rise in blood glucose after consumption; higher levels indicate a more rapid, higher increase.

#### Factors Affecting the GI of a Food

A variety of factors affect the GI of an individual food (5). These include:

- Ripeness of fruits and vegetables
  - As the starch in fruit is converted to sugar during ripening, the GI becomes higher.
- Physical form of the food (whole versus mashed versus juice)
  - The whole form of a food will generally have a lower GI than the mashed/pureed form, which has a lower GI than the juice form.
- Different types of food within a class
  - For example, different types of rice, potatoes and pastas have different GIs because of the proportion of the types of starch in the grain.
- Processing
  - Grinding, rolling, pressing and thoroughly chewing can increase the GI.
- Preparation method and length of cooking
  - When a starchy food such as a potato is cooked, the starch becomes more digestible. When it is allowed to stand after cooking, a portion of the starch forms a gel that is resistant to digestion. The more a starch-containing food is heated, moisturized, ground or pressed, the more amenable it will be to digestion, except for the portion that forms insoluble complexes that are resistant to digestion.
- Composition of the meal
  - The GI of an individual food will be changed when it is consumed with other foods. Generally, meals or snacks also contain protein, fat and/or fiber, which will also affect blood sugar levels through effects on absorption or insulin secretion. Foods high in fat in particular will slow the rate of emptying from the stomach.
  - Increasing the acidity of a meal can also lower the GI.

#### Glycemic Load

More recently, the concept of the *glycemic load* has been introduced (6). The glycemic load considers both the total amount of carbohydrate in the portion consumed and the GI of that food. The glycemic load of a particular food is the product of the GI of the food

and amount of carbohydrate in the serving. The glycemic load is considered to be more useful because it considers both the quality and quantity of carbohydrate consumed. The use of glycemic load values allows comparison of the likely glycemic effect of realistic portions of different foods. Consider the following example:

The GI of orange juice is 50. To determine this, the amount of orange juice that was compared to glucose was approximately 2 cups. One standard serving of orange juice is ½ cup, which provides 13 grams of carbohydrate. The glycemic load is determined by multiplying the GI of orange juice [50] times the grams of carbohydrate in the serving [13], and dividing by 100. Thus the glycemic load of ½ cup of orange juice is 6.5. A typical serving of orange juice is 1 cup, which has 26 grams of available carbohydrate. The glycemic load of 1 cup of orange juice is 13.

When the glycemic load is higher, the increase in blood glucose would be expected to be higher.

### **Evaluating Research on Glycemic Index and Glycemic Load**

Many of the studies that are investigating the clinical relevance of the GI and glycemic load are based on studies of populations. These studies, called epidemiological studies, relate characteristics and behaviors of the population to the extent of disease in that population. While these types of studies do suggest relationships between two factors, they do not give evidence of causation.

Laboratory studies in both animals and humans can provide information about the relationship and how it operates. These studies are usually designed to answer a focused question and are very controlled. However, they tend to be less representative of real-life situations. Generally, the results are used with results of other studies to develop a hypothesis about what may be occurring in real life.

Clinical intervention studies are needed to establish causation and result from observations of epidemiological and laboratory studies. In order to test a theory, they need to be well designed, include adequate (usually large) numbers of subjects, be carried out for a sufficient length of time, and utilize precise measurements. In these studies, participants are randomly assigned to an intervention or no-intervention (control) group, and subsequently followed. At the end of the study period, the two groups are compared on outcomes such as weight change, change in cholesterol and blood lipids, or blood glucose responses. To establish more conclusive relationships, these studies usually need to be conducted for long periods of time with a large number of participants, making them very costly. Smaller intervention trials can provide the same information as large-scale trials when, upon replication, they show the same results.

To date, large-scale intervention studies utilizing GI have not been conducted, and there are too few smaller intervention trials. Epidemiological, laboratory and a few small

intervention studies have provided the current knowledge on GI. What does the research tell about GI, glycemic load and health?

### **Glycemic Index and Diabetes Management**

The GI was originally proposed as a tool for management of type 1 diabetes. In type 1 diabetes, insulin is needed to maintain normal blood glucose levels. A recent analysis of all the randomized controlled trials that have examined the efficacy of the GI on overall blood glucose control in people with diabetes indicates that the use of this technique can provide an additional benefit over that observed when total carbohydrate is considered alone (7). The use of the GI in diabetes management is recommended in Canada, Australia and Europe. However, in the United States, it has not gained wide acceptance as a component of treatment for diabetes because of the controversy surrounding its practicality and potential benefit. Its use has been suggested as a potential method to 'fine-tune' blood glucose control (8).

The American Diabetes Association issued a statement in September 2004 on dietary carbohydrate in the prevention and management of diabetes (9). Based on review of the most recent literature, people with diabetes are encouraged to consider several important points for the use of the GI in the management of diabetes.

1. Since the GI provides only a measure of the quality of a single carbohydrate food, it should not be used alone, but rather in conjunction with other food and nutrition strategies.
2. The GI for any particular single food varies considerably. This variation may be a result of characteristics of the food itself or of the individual consuming the food.
3. The GI only measures the response to an individual food consumed alone.
4. The GI does not predict postprandial (following a meal) blood glucose response as accurately in individuals with diabetes as it does in healthy persons.

The statement concluded that the total amount of carbohydrate is a strong predictor of glycemic response, and thus, **monitoring total grams of carbohydrate**, whether by use of exchanges or carbohydrate counting, remains a key strategy in achieving control of blood glucose in the normal range

## **GLYCEMIC INDEX, GLYCEMIC LOAD, AND HEALTH**

### **Are High GI Foods Harmful to Health?**

It has been suggested that foods with a high GI are detrimental to health and that healthy people should be told to avoid these foods (5). Specifically, consuming high GI foods has been purported to increase risk for diabetes, obesity, heart disease and cancer.

One theory behind foods with a high GI as a cause of these diseases is related to insulin (5). When high GI foods are consumed, insulin levels rapidly increase in the blood in

response to the rapid increase in blood sugar. This high insulin response is alleged to promote increased food intake leading to obesity, insulin resistance (an inability of the cells to respond to insulin, leaving levels of glucose high in the blood), 'wearing out' cells of the pancreas that produce insulin (called 'beta-cells'), and high levels of lipids in the blood, leading to cardiovascular disease.

### ***Do High GI Foods Cause Diabetes?***

The claim that a diet which contains a high GI and glycemic load leads to diabetes is based on two large epidemiological studies where this relationship was observed. However, this does not imply causation. Additionally, the precision of the methods to measure dietary intake that was used in these studies has been questioned (5). Although some clinical studies suggest mechanisms that explain this possible relationship (10), there are also studies which have observed that diets high in fat and low in carbohydrate were associated with an increased risk for diabetes, whereas low fat, high carbohydrate diets were associated with a decreased risk (5). Additionally, studies do not support that the intake of high GI foods leads to insulin resistance or exhaustion of cells of the pancreas that produce insulin (5). In fact, several intervention studies actually demonstrated greater insulin sensitivity with a high carbohydrate diet (5).

### ***GI, food intake and obesity***

In general, results of studies investigating the effects of GI, food intake and obesity are mixed and inconclusive.

Foods that are high in GI are purported to increase food intake. Studies that have looked at the response to a single meal have shown mixed results; some showed an increase in food intake while others did not (5). Several studies (11) have shown that when the first meal of the day is low in GI and glycemic load, less food is consumed in subsequent meals of the day. However, there is no evidence that insulin, at concentrations found in humans in response to carbohydrate intake, triggers weight gain by increasing hunger. (5)

High GI foods are also thought to favor utilization of calories in such a way that leads to body fat gain. Although some laboratory and short-term clinical trials support this concept (11), two studies that followed subjects to observe the effect of a high GI diet compared to a low GI diet *over time* did *not* find an effect of a high GI diet on body weight. (5)

### ***GI, glycemic load and cardiovascular disease***

Several large studies suggest a relationship between GI, glycemic load and cardiovascular disease. In a large epidemiologic study that followed 75,000 women for 10 years, glycemic load of the diet was related to coronary heart disease (12). However, the measurement of intake used in the study is considered imprecise. In two other studies that related dietary GI to cardiac risk factors, a low GI diet was found to increase HDL cholesterol – the 'healthy' form. (13)

Results from laboratory and small, short-term clinical studies that have investigated relationships of GI and glycemic load to cardiovascular diseases have also been

interesting. In summary, low GI diets have had a positive effect on risk factors such as blood lipids in people with coronary artery disease or with a history of coronary artery disease, in persons who have abnormalities of blood lipids, and in people with diabetes. However, long-term intervention studies are needed to confirm the potential effectiveness of low GI diets in prevention of cardiovascular diseases.

### ***GI, glycemic load and cancer***

Epidemiological studies have also suggested relationships between GI, glycemic load and different cancers (14). Further research is necessary to identify potential mechanisms and effectiveness of interventions that use GI and glycemic load to prevent cancer.

## **A CLOSER LOOK AT HIGH GLCEMIC INDEX FOODS**

Based on the research, it is too soon to make the recommendation to choose a diet based solely on low GI foods in order to lose weight, prevent cardiovascular disease, diabetes and cancer. However, inspection of those foods that are low GI versus high GI will show that, while not true across the board, low GI foods will tend to be those foods that are recommended for a healthy diet by the *Dietary Guidelines for Americans 2005*. They tend to be low in calories and fat, and high in fiber and antioxidants.

Most fruits and vegetables are low GI foods. High fiber, minimally processed foods such as whole grains and whole grain products, and legumes also tend to have lower GI values than highly processed foods. Yogurt and milk have low GI values as well.

However, there are exceptions, and a certain amount of understanding is required for utilizing the GI when choosing foods. For example, carrots and potatoes have a high GI. Should they be avoided or eliminated from the diet? Absolutely not! Since carrots are a low energy food, the high GI is not going to be significant because the ratio of other desirable factors (vitamins, minerals, fiber, phytochemicals) to available carbohydrate is high. This is true for several other fruits and vegetables as well.

Conversely, the GI values of ice cream and chocolate bars would categorize them as low GI foods. Does that mean they can be consumed freely? They provide minimal contribution of vitamins, minerals and phytochemicals in relation to their high calorie content and should be consumed only occasionally,

More research is needed to clarify relationships between GI, glycemic load and health. In order to establish convincing evidence of relationships between GI and health, short-term studies need to be repeated and long-term intervention studies need to be conducted.

The GI may be a tool to guide the consumer to choose starchy foods that they may not be currently consuming (14). Given that many foods that have a low GI value have important health benefits, it may facilitate healthier choices. For those who are considering the use of the GI as part of a food choice strategy, there are several important caveats.

- The quality AND quantity of carbohydrate consumed is important.
  - Some nutritious foods have high GI values; however, consumption of these foods should not be avoided. They are low in calories with high nutritional benefit.
  - Less healthful foods that have a low GI value should not be consumed freely. They provide excess calories with minimal nutrition benefits.
- GI values vary depending on how the food is prepared and consumed, degree of processing, and composition of the meal.
  - Although fat lowers the GI of a food, there are still adverse health consequences to high fat consumption, especially animal fat. The *Dietary Guidelines for Americans 2005* recommend that a range of 20-35% of calories be consumed from fat, primarily from vegetables sources, and less than 10% should be from animal fat (3).

As a guide (15), categories of GI and glycemic load are:

	<u>Glycemic Index</u>	<u>Glycemic Load</u>	<u>Glycemic Load/day</u>
LOW	55 or less	10 or less	less than 80
MEDIUM	56 -69	11-19	
HIGH	70 or greater	20 or greater	greater than 120

## **OTHER SOURCES OF INFORMATION ON GLYCEMIC INDEX**

More information about how the GI can be used for food selection can be found at the following sources.

Canadian Diabetes Association:

Provides practical information on how to use the GI to choose foods wisely.

[www.diabetes.ca/Section\\_About/glycemic.asp](http://www.diabetes.ca/Section_About/glycemic.asp)

Prevention:

Contains a consumer friendly list of the GI values of foods.

<http://www.prevention.com/article/0,5778,s1-3-61-114-2636-1,00.html>

University of Sydney, Australia

Contains information on GI and use of the GI symbol in Australia.

[www.glycemicindex.com](http://www.glycemicindex.com)

American Journal of Clinical Nutrition, 2002, Volume 76: pages 5-56.

“International table of GI and glycemic load values: 2002.”

Updated list of GI and glycemic load values.

<http://www.ajcn.org/cgi/reprint/76/1/5>

## REFERENCES

1. Jenkins DJA, Wolever TMS, Taylor Rh et. Al. Glycemic index of foods; a physiological basis for carbohydrate exchange. *Am J Clin Nutr* 1981; 34: 362-6
2. Institute of Medicine of the National Academies of Science, Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients) (2002), The National Academies Press
3. Department of Health and Human Services, U.S. Department of Agriculture. Dietary Guidelines for Americans 2005.
4. U.S. Department of Agriculture, Agricultural Research Service. 2004. USDA National Nutrient Database for Standard Reference, Release 17. Nutrient Data Laboratory Home Page, <http://www.nal.usda.gov/fnic/foodcomp>
5. Pi-Sunyer FX. *Am J Clin Nutr*. 2002; 76(suppl): 290S-8S
6. Salmeron J, Manson JE, Stampfer MJ, Colditz GA, Wing AI, Willett WC. Dietary fiber, glycemic load, and risk of non-insulin-dependent diabetes mellitus in women. *JAMA* 1997; 277:472-7.
7. Brand-Miller J, Hayne S, Petocz P, Colagiuri S. Low-glycemic index diets in the management of diabetes. *Diabetes Care* 2003, 26(8):2261-2267.
8. Franz M. The glycemic index: not the most effective nutrition therapy intervention. [Editorial re: Brand-Miller J et.al. in *Diabetes Care* 26(8): 2261-2267] *Diabetes Care* 2003, 26(8): 2466-2468.
9. Sheard NF, Pi-Sunyer FX, Clark NG et. al. Dietary Carbohydrate (Amount and Type) in the Prevention and Management of Diabetes: a statement by the American Diabetes Association. *Diabetes Care* 2004, 27(9): 2266-2271.
10. Willett W, Manson J, Liu S. Glycemic index, glycemic load, and risk of type 2 diabetes. *Am J Clin Nutr* 2002; 76 (suppl):274S – 80S.
11. Brand-Miller JC, Holt SHA, Pawlak DB, and McMillan J. GI and obesity. *Am J Clin Nutr* 2002; 76(suppl):281S-5S.
12. Liu S, Willett WC, Stampfer MJ et.al. A prospective study of dietary glycemic load, carbohydrate intake, and risk of coronary heart disease in US women. *Am J Clin Nutr* 2000; 71:1455-61.
13. Leeds AR. Glycemic index and heart disease. *Am J Clin Nutr* 2002, 76 (suppl): 286S-9S.

14. Jenkins DJA, Kendall CWC, Augustin LSA, et. al. Glycemic index: overview of implications in health and disease. *Am J Clin Nutr* 2002; 76(suppl): 266S-73S.
15. University of Sydney, <http://www.glycemicindex.com>